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(54) **ACTIVE NOISE CONTROL SYSTEM**

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Description

[0001] The present invention relates to a technique of active noise control (ANC) for reducing noise by radiating a noise cancellation sound to cancel noise.

[0002] As an active noise control technique for reducing noise by radiating a noise cancellation sound to cancel noise, a technique is known in which a microphone and a speaker arranged near a noise cancellation position and an adaptive filter, which generates a noise cancellation sound output from the speaker by applying a transfer function adaptively set to an output signal of a noise source or a signal simulating the output signal, are provided and the transfer function is adaptively set as an error signal obtained by correcting the output of the microphone using an auxiliary filter in the adaptive filter.

[0003] Here, in this technique, transfer functions for correcting the difference between a transfer function from the noise source to the noise cancellation position and a transfer function from the noise source to the microphone and the difference between a transfer function from the speaker to the noise cancellation position and a transfer function from the speaker to the microphone, which are learned in advance, are set in the auxiliary filter. By using such an auxiliary filter, noise is canceled at a noise cancellation position different from the position of the microphone.

[0004] US 2008/317254 A1 discloses a noise control device which comprises four or more noise detectors each for detecting a plurality of noises, and outputting the noises as a noise signal, a control speaker for radiating, to a control point, a control sound based on each noise signal, and a filter section for signal-processing noise signals from the noise detectors by using filter coefficients which respectively correspond to the four or more noise detectors and which are set such that the control sound from the control speaker reduces the plurality of noises arriving at the control point, and for adding up all the signal-processed noise signals, and for outputting a resultant signal to the control speaker. The control point and the control speaker are provided within a polyhedral-shaped space whose apexes are placement positions of the noise detectors.

[0005] In addition, a technique is also known in which a set of a microphone, a speaker, an adaptive filter, and an auxiliary filter corresponding to each of two noise cancellation positions is provided and a noise cancellation sound to cancel noise at the corresponding noise cancellation position in each set is output using the technique described above, so that the noise generated from a noise source is canceled at each of the two noise cancellation positions (for example, JP 2018-72770 A).

[0006] In order to cancel the noise heard by a user sitting in a seat, when the standard positions of the right ear and the left ear of the user sitting in the seat are set to two noise cancellation positions and the noise generated from the noise source is canceled at each of the two noise cancellation positions by the technique described

above, if the right ear and the left ear of the user are shifted from the noise cancellation positions due to the displacement of the user due to the movement of the seat or the movement of the user sitting in the seat, the noise heard by the user may not be canceled satisfactorily.

[0007] Therefore, it is an object of the present invention to provide an active noise control system for canceling noise heard by a user without being easily affected by the displacement of the user.

[0008] The invention relates to an active noise control system and vehicle comprising such active noise control system according to the independent claims. Embodiments are disclosed in the dependent claims. According to an aspect of the present invention, an active noise control system for reducing noise includes: a first speaker configured to output a first cancellation sound; a second speaker configured to output a second cancellation sound; and a cancellation sound generation unit that generates the first cancellation sound output from the first speaker and the second cancellation sound output from the second speaker such that noise is canceled at a first cancellation point set in advance and noise is canceled at a second cancellation point set in advance. The first speaker and the second speaker are arranged side by side in a direction perpendicular to a line segment connecting the first cancellation point and the second cancellation point to each other such that positions of the first speaker and the second speaker in a direction of the line segment are located between the first cancellation point and the second cancellation point. Here, in the active noise control system the first cancellation point and the second cancellation point are a point where a left ear of a person sitting in a predetermined seat is normally located and a point where a right ear of the user is normally located, respectively.

[0009] Here, in such an active noise control system, it is preferable that the first speaker and the second speaker are arranged side by side in the direction perpendicular to the line segment connecting the first cancellation point and the second cancellation point to each other such that the positions of the first speaker and the second speaker in the direction of the line segment are the same as a midpoint of the first cancellation point and the second cancellation point.

[0010] In addition, the predetermined seat may be a seat of a vehicle, and the first speaker and the second speaker may be arranged side by side in a front-rear direction of the vehicle on a ceiling in front of the seat of the vehicle.

[0011] In the active noise control system, the cancellation sound generation unit may include a first microphone, a second microphone, a first adaptive filter configured to receive a noise signal indicating the noise and generate the first cancellation sound, and a second adaptive filter configured to receive a noise signal indicating the noise and generate the second cancellation sound. Here, the first adaptive filter and the second adaptive filter adapt their own transfer functions as the first can-

cancellation sound output from the first speaker and the second cancellation sound output from the second speaker, using an input sound from each of the first microphone and the second microphone, so that noise is canceled at the first cancellation point and noise is canceled at the second cancellation point.

[0012] In addition, the cancellation sound generation unit may include a first auxiliary filter and a second auxiliary filter, and the first adaptive filter and the second adaptive filter may be configured to update their own transfer functions respectively set therein using a predetermined adaptive algorithm with a difference between the input sound from the first microphone and an output of the first auxiliary filter and a difference between the input sound from the second microphone and an output of the second auxiliary filter as errors. When a transfer function in which noise is canceled at the first cancellation point and the second cancellation point is set in the first adaptive filter and the second adaptive filter, the respective transfer function learned as a transfer function that eliminates the difference between the input sound from the first microphone and the output of the first auxiliary filter and the difference between the input sound from the second microphone and the output of the second auxiliary filter may be set in the first auxiliary filter and the second auxiliary filter.

[0013] According to the active noise control system, a range near the first cancellation point, at which the phase (distance) of the first cancellation sound output from the first speaker and the phase (distance) of the second cancellation sound output from the second speaker are the same as those at the first cancellation point, and a range near the second cancellation point, at which the phase of the first cancellation sound output from the first speaker and the phase of the second cancellation sound output from the second speaker are the same as those at the second cancellation point, can be set to be a relatively wide range. Therefore, it is possible to realize noise cancellation that is not easily affected by the displacement of the user.

[0014] According to the present invention, it is possible to provide the active noise control system for canceling the noise heard by the user without being easily affected by the displacement of the user.

Fig. 1 is a block diagram illustrating the configuration of an active noise control system according to an embodiment of the present invention.

Figs. 2A1 and 2A2 are diagrams illustrating an arrangement of speakers and microphones in the active noise control system according to an embodiment of the present invention.

Fig. 3 is a block diagram illustrating the configuration of a signal processing block according to an embodiment of the present invention.

Figs. 4A and 4B are diagrams illustrating an operation of the active noise control system according to an embodiment of the present invention.

Figs. 5A and 5B are diagrams illustrating another configuration example of the active noise control system according to an embodiment of the present invention.

[0015] Hereinafter, embodiments of the present invention will be described.

[0016] Fig. 1 illustrates the configuration of an active noise control system according to an embodiment.

[0017] As illustrated in Fig. 1, an active noise control system 1 includes a signal processing block 11, a first speaker 12, a first microphone 13, a second speaker 14, and a second microphone 15.

[0018] Preferably, the active noise control system 1 is a system installed in a vehicle, and is a system for canceling noise generated by a noise source 2 at each of two cancellation points of a first cancellation point, which is the position of the right ear of the user seating in a predetermined seat in the vehicle, and a second cancellation point, which is the position of the left ear of the user.

[0019] Here, as illustrated in Figs. 2A1 and 2A2, the first speaker 12 and the second speaker 14 are arranged side by side in the front-rear direction of the vehicle on the ceiling in front of a noise cancellation target seat that is a seat (right front seat in the diagram) where the user sits and which is a target of noise cancellation in the vehicle. In addition, the first speaker 12 and the second speaker 14 are arranged such that the positions of the first speaker 12 and the second speaker 14 in the right-left direction of the vehicle match the position of the center of the noise cancellation target seat in the right-left direction. In other words, in the present embodiment, the first speaker 12 and the second speaker 14 are arranged side by side in a direction (front-rear direction of the vehicle) perpendicular to a line segment connecting the first cancellation point and the second cancellation point to each other such that the positions of the first speaker 12 and the second speaker 14 in the line segment direction (right-left direction of the vehicle) are the same as the midpoint of the first cancellation point and the second cancellation point.

[0020] In addition, as illustrated in Figs. 2A1 and 2A2, the first microphone 13 is arranged, for example, on the ceiling in front of the standard position of the right ear of the user sitting in the noise cancellation target seat, and the second microphone 15 is arranged, for example, on the ceiling in front of the standard position of the left ear of the user sitting in the noise cancellation target seat.

[0021] Referring back to Fig. 1, using a noise signal $x(n)$ indicating the noise generated by the noise source 2, a first microphone error signal $err1(n)$ that is a voice signal picked up by the first microphone 13, and a second microphone error signal $err2(n)$ that is a voice signal picked up by the second microphone 15, the signal processing block 11 of the active noise control system 1 generates a first cancellation signal $CA1(n)$ and outputs the first cancellation signal $CA1(n)$ from the first speaker 12, and generates a second cancellation signal $CA2(n)$

and outputs the second cancellation signal CA2(n) from the second speaker 14.

[0022] Here, the first cancellation signal CA1(n) output from the first speaker 12 cancels the noise generated by the noise source 2 at the first cancellation point together with the second cancellation signal CA2(n) output from the second speaker 14. In addition, the second cancellation signal CA2(n) output from the second speaker 14 cancels the noise generated by the noise source 2 at the second cancellation point together with the first cancellation signal CA1(n) output from the first speaker 12.

[0023] Next, Fig. 3 illustrates a configuration of the signal processing block 11 of the active noise control system 1.

[0024] The signal processing block 11 includes a first signal processing unit 111 that mainly performs processing relevant to the generation of the first cancellation signal CA1(n) and a second signal processing unit 112 that mainly performs processing relevant to the generation of the second cancellation signal CA2(n).

[0025] Then, as illustrated in Fig. 3, the first signal processing unit 111 includes a first system auxiliary filter 1111 in which a transfer function $H_1(z)$ is set in advance, a first system variable filter 1112, a first system adaptive algorithm execution unit 1113, a first system first estimation filter 1114 in which a transfer function $S_{11}^{\wedge}(z)$ is set in advance, a first system second estimation filter 1115 in which a transfer function $S_{21}^{\wedge}(z)$ is set in advance, and a first system subtractor 1116.

[0026] In such a configuration of the first signal processing unit 111, the input noise signal $x(n)$ is output to the first speaker 12 as the first cancellation signal CA1(n) through the first system variable filter 1112.

[0027] In addition, the input noise signal $x(n)$ is transmitted to the first system subtractor 1116 through the first system auxiliary filter 1111, and the first system subtractor 1116 subtracts the output of the first system auxiliary filter 1111 from the first microphone error signal $err1(n)$ picked up by the first microphone 13 and outputs the result, as an error $e1$, to the first system adaptive algorithm execution unit 1113 and the second signal processing unit 112.

[0028] Then, the first system variable filter 1112, the first system adaptive algorithm execution unit 1113, the first system first estimation filter 1114, and the first system second estimation filter 1115 form a multiple error filtered-X adaptive filter. In the first system first estimation filter 1114, an estimated transfer characteristic $S_{11}^{\wedge}(z)$ of a transfer function $S_{11}(z)$ from the first signal processing unit 111 to the first microphone 13 calculated by actual measurement or the like is set in advance. The first system first estimation filter 1114 convolves the input noise signal $x(n)$ with the transfer characteristic $S_{11}^{\wedge}(z)$, and inputs the resultant signal to the first system adaptive algorithm execution unit 1113. In addition, in the first system second estimation filter 1115, an estimated transfer characteristic $S_{21}^{\wedge}(z)$ of a transfer function $S_{21}(z)$ indicating a transfer function from the first signal process-

ing unit 111 to the second microphone 15 calculated by actual measurement or the like is set in advance. The first system second estimation filter 1115 convolves the input noise signal $x(n)$ with the transfer characteristic $S_{21}^{\wedge}(z)$, and inputs the resultant signal to the first system adaptive algorithm execution unit 1113.

[0029] Then, the first system adaptive algorithm execution unit 1113 receives the noise signal $x(n)$ in which the transfer function $S_{11}^{\wedge}(z)$ is convoluted by the first system first estimation filter 1114, the noise signal $x(n)$ in which the transfer function $S_{21}^{\wedge}(z)$ is convoluted by the first system second estimation filter 1115, the error $e1$ output from the first system subtractor 1116, and an error $e2$ output from the second signal processing unit 112, and executes an adaptive algorithm, such as NLMS, and updates a transfer function $W_1(z)$ of the first system variable filter 1112 so that the error $e1$ and the error $e2$ become 0.

[0030] The second signal processing unit 112 has the same configuration as the first signal processing unit 111, and the second signal processing unit 112 includes a second system auxiliary filter 1121 in which a transfer function $H_2(z)$ is set in advance, a second system variable filter 1122, a second system adaptive algorithm execution unit 1123, a second system first estimation filter 1124 in which a transfer function $S_{22}^{\wedge}(z)$ is set in advance, a second system second estimation filter 1125 in which a transfer function $S_{12}^{\wedge}(z)$ is set in advance, and a second system subtractor 1126.

[0031] In such a configuration of the second signal processing unit 112, the input noise signal $x(n)$ is output to the second speaker 14 as the second cancellation signal CA2(n) through the second system variable filter 1122.

[0032] In addition, the input noise signal $x(n)$ is transmitted to the second system subtractor 1126 through the second system auxiliary filter 1121, and the second system subtractor 1126 subtracts the output of the second system auxiliary filter 1121 from the second microphone error signal $err2(n)$ picked up by the second microphone 15 and outputs the result, as an error $e2$, to the second system adaptive algorithm execution unit 1123 and the first signal processing unit 111.

[0033] Then, the second system variable filter 1122, the second system adaptive algorithm execution unit 1123, the second system first estimation filter 1124, and the second system second estimation filter 1125 form a multiple error filtered-X adaptive filter. In the second system first estimation filter 1124, an estimated transfer characteristic $S_{22}^{\wedge}(z)$ of a transfer function $S_{22}(z)$ from the second signal processing unit 112 to the second microphone 15 calculated by actual measurement or the like is set in advance. The second system first estimation filter 1124 convolves the input noise signal $x(n)$ with the transfer characteristic $S_{22}^{\wedge}(z)$, and inputs the resultant signal to the second system adaptive algorithm execution unit 1123. In addition, in the second system second estimation filter 1125, an estimated transfer characteristic

$S_{12}^{\wedge}(z)$ of a transfer characteristic $S_{12}(z)$ indicating a transfer function from the second signal processing unit 112 to the first microphone 13 calculated by actual measurement or the like is set in advance. The second system second estimation filter 1125 convolves the input noise signal $x(n)$ with the transfer characteristic $S_{12}^{\wedge}(z)$ and inputs the resultant signal to the second system adaptive algorithm execution unit 1123.

[0034] Then, the second system adaptive algorithm execution unit 1123 receives the noise signal $x(n)$ in which the transfer function $S_{22}^{\wedge}(z)$ is convoluted by the second system first estimation filter 1124, the noise signal $x(n)$ in which the transfer function $S_{12}^{\wedge}(z)$ is convoluted by the second system second estimation filter 1125, the error $e2$ output from the second system subtractor 1126, and the error $e1$ output from the first signal processing unit 111, executes an adaptive algorithm, such as NLMS, and updates a transfer function $W_2(z)$ of the second system variable filter 1122 so that the error $e1$ and the error $e2$ become 0.

[0035] Here, the first system auxiliary filter 1111 of the first signal processing unit 111 is provided to correct the difference between the positions of the first microphone 13 and the first cancellation point and the first microphone error signal $err1(n)$, and the second system auxiliary filter 1121 of the second signal processing unit 112 is provided to correct the difference between the positions of the second microphone 15 and the second cancellation point and the second microphone error signal $err2(n)$.

[0036] In addition, the transfer function $H_1(z)$ set in the first system auxiliary filter 1111 of the first signal processing unit 111 and the transfer function $H_2(z)$ set in the second system auxiliary filter 1121 of the second signal processing unit 112 are transfer functions set in advance by learning. As a transfer function in which noise is canceled at each of the first cancellation point and the second cancellation point and which is obtained by placing a microphone for learning at the first cancellation point and the second cancellation point under the environment at the time of learning, the transfer function $H_1(z)$ and the transfer function $H_2(z)$ are set in which the error $e1$ output from the first system subtractor 1116 and the error $e2$ output from the second system subtractor 1126 are 0 and which are obtained in a state in which the transfer functions of the first system variable filter 1112 and the second system variable filter 1122 are fixed.

[0037] In addition, the transfer functions of the first system variable filter 1112 and the second system variable filter 1122 in which noise is canceled at each of the first cancellation point and the second cancellation point change from those under the environment at the time of learning due to a change in the environment. Reflecting this change in the transfer functions of the first system variable filter 1112 and the second system variable filter 1122 is the update of the transfer function by the adaptive algorithm, such as the above-described NLMS.

[0038] Incidentally, here, in a range near the first cancellation point, it can be considered that the noise prop-

agates in the same manner as at the first cancellation point. Therefore, at a position within the range near the first cancellation point, at which the phase (distance) of the first cancellation signal $CA1(n)$ output from the first speaker 12 and the phase (distance) of the second cancellation signal $CA2(n)$ output from the second speaker 14 are the same as those at the first cancellation point, the relationship between the noise and the first cancellation signal $CA1(n)$ and the second cancellation signal $CA2(n)$ is the same as that at the first cancellation point. For this reason, the effect of noise cancellation can be expected.

[0039] Similarly, in a range near the second cancellation point, it can be considered that the noise propagates in the same manner as at the second cancellation point. Therefore, at a position within the range near the second cancellation point, at which the phase of the first cancellation signal $CA1(n)$ output from the first speaker 12 and the phase of the second cancellation signal $CA2(n)$ output from the second speaker 14 are the same as those at the second cancellation point, the relationship between the noise and the first cancellation signal $CA1(n)$ and the second cancellation signal $CA2(n)$ is the same as that at the second cancellation point. For this reason, the effect of noise cancellation can be expected.

[0040] In addition, as described above, in the present embodiment, the first speaker 12 and the second speaker 14 are arranged side by side in a direction (front-rear direction of the vehicle) perpendicular to the line segment connecting the first cancellation point and the second cancellation point to each other such that the positions of the first speaker 12 and the second speaker 14 in the line segment direction (right-left direction of the vehicle) are the same as the midpoint of the first cancellation point and the second cancellation point.

[0041] Fig. 4A is a two-dimensional schematic diagram when it is assumed that reference numeral 41 is a first cancellation point, reference numeral 42 is a second cancellation point, a region between adjacent circles of concentric circles having the first speaker 12 as the center is a range where the phase of the first cancellation signal $CA1(n)$ is the same, and a region between adjacent circles of concentric circles having the second speaker 14 as the center is a range where the phase of the second cancellation signal $CA2(n)$ is the same. A range where the phase of the first cancellation signal $CA1(n)$ output from the first speaker 12 and the phase of the second cancellation signal $CA2(n)$ output from the second speaker 14 are the same as those at the first cancellation point 41 and a range where the phase of the first cancellation signal $CA1(n)$ output from the first speaker 12 and the phase of the second cancellation signal $CA2(n)$ output from the second speaker 14 are the same as those at the second cancellation point 42 are all a range 400 surrounded by a thick line.

[0042] Therefore, within the range 400, in a range near the first cancellation point 41 where noise propagates in the same manner as at the first cancellation point 41, the

same noise cancellation effect as at the first cancellation point 41 can be obtained. In addition, within the range 400, in a range near the second cancellation point 42 where noise propagates in the same manner as at the second cancellation point 42, the same noise cancellation effect as at the second cancellation point 42 can be obtained.

[0043] On the other hand, when the first speaker 12 is located in front of the right ear of the user sitting in the noise cancellation target seat, which is the first cancellation point, and the second speaker 14 is located in front of the left ear of the user sitting in the noise cancellation target seat, which is the second cancellation point, so that the first speaker 12 and the second speaker 14 are arranged side by side in the right-left direction of the vehicle, as illustrated in Fig. 4B, the range where the phase of the first cancellation signal CA1(n) output from the first speaker 12 and the phase of the second cancellation signal CA2(n) output from the second speaker 14 are the same as those at the first cancellation point 41 is a range 411 surrounded by the thick line, and the range where the phase of the first cancellation signal CA1(n) output from the first speaker 12 and the phase of the second cancellation signal CA2(n) output from the second speaker 14 are the same as those at the second cancellation point 42 is a range 412 surrounded by the thick line. Both the ranges 411 and 412 are narrower than the range 400 when the first speaker 12 and the second speaker 14 are arranged as illustrated in Fig. 4A.

[0044] Therefore, as in the present embodiment, the first speaker 12 and the second speaker 14 are arranged side by side in a direction perpendicular to the line segment connecting the first cancellation point and the second cancellation point to each other such that the positions of the first speaker 12 and the second speaker 14 in the line segment direction are the same as the midpoint of the first cancellation point and the second cancellation point. As a result, it is possible to cancel the noise heard by the user without being easily affected by the displacement of the user.

[0045] In addition, the distance between the first speaker 12 and the second speaker 14 and the first cancellation point 41 and the second cancellation point 42 in the front-rear direction of the vehicle in Fig. 4B is the average of the distances between the first speaker 12 and the second speaker 14 and the first cancellation point 41 and the second cancellation point 42 in the front-rear direction of the vehicle in Fig. 4A.

[0046] The positions of the first speaker 12 and the second speaker 14 in the direction of the line segment connecting the first cancellation point and the second cancellation point to each other do not have to be exactly the same as the midpoint of the first cancellation point and the second cancellation point, and the positions of the first speaker 12 and the second speaker 14 in the line segment direction may be any positions between the first cancellation point and the second cancellation point. Even in this case, some effect can be expected.

[0047] In addition, in the above embodiments, a case where the noise cancellation is performed for a user in one seat of the vehicle has been described. However, as illustrated in Figs. 5A and 5B, the first speaker 12, the first microphone 13, the second speaker 14, and the second microphone 15 may be provided for each seat of the vehicle to cancel the noise for the user in each seat.

[0048] In addition, in the above embodiments, the noise signal $x(n)$ input to the active noise control system 1 may be an audio signal output from the noise source 2, or a voice signal picked up by a noise microphone provided separately, or a signal generated by a simulation sound generator, which is provided separately, to simulate the noise of the noise source.

[0049] That is, for example, when the noise source 2 is an engine, the noise signal $x(n)$ may be an engine sound picked up by a separate noise microphone or may be a simulation sound generated by a simulation sound generator, which is provided separately, to simulate the engine sound.

[0050] In addition, in the above embodiments, the signal processing block 11 may perform any signal processing different from that illustrated above as long as the first cancellation signal CA1(n) is generated and output from the first speaker 12 and the second cancellation signal CA2(n) is generated and output from the second speaker 14 so that the noise is canceled at both the first cancellation point and the second cancellation point.

[0051] In addition, in the above embodiments, a case where the noise cancellation is performed for a user in a seat of the vehicle has been described. However, this can be similarly applied to the case of canceling noise at any two cancellation points including a case where the noise cancellation is performed for both ears of the user in any seat of the vehicle.

[0052] In addition, in the above embodiments, a case where there is only one noise source has been described. However, the above embodiment can also be applied to a case where there is a plurality of noise sources by extending the configuration of the signal processing block 11 so as to consider the propagation of noise from each noise source to each cancellation point.

Reference Signs List

[0053]

1	Active noise control system
2	Noise source
11	Signal processing block
12	First speaker
13	First microphone
14	Second speaker
15	Second microphone
111	First signal processing unit
112	Second signal processing unit
1111	First system auxiliary filter
1112	First system variable filter

1113 First system adaptive algorithm execution unit
 1114 First system first estimation filter
 1115 First system second estimation filter
 1116 First system subtractor
 1121 Second system auxiliary filter
 1122 Second system variable filter
 1123 Second system adaptive algorithm execution unit
 1124 Second system first estimation filter
 1125 Second system first estimation filter
 1126 Second system subtractor

Claims

1. An active noise control system (1) for reducing noise, comprising:

a first speaker (12) configured to output a first cancellation sound;
 a second speaker (14) configured to output a second cancellation sound; and
 a cancellation sound generation unit that is configured to generate the first cancellation sound output from the first speaker (12) and the second cancellation sound output from the second speaker (14) such that noise is canceled at a first cancellation point (41) set in advance and noise is canceled at a second cancellation point (42) set in advance, wherein the first cancellation point (41) and the second cancellation point (42) are a point where a left ear of a person sitting in a predetermined seat is normally located and a point where a right ear of a user is normally located, respectively,
characterized in that the first speaker (12) and the second speaker (14) are arranged side by side in a direction perpendicular to a line segment connecting the first cancellation point (41) and the second cancellation point (42) to each other such that positions of the first speaker (12) and the second speaker (14) in a direction of the line segment are located between the first cancellation point (41) and the second cancellation point (42).

2. The active noise control system (1) according to claim 1, wherein
 the first speaker (12) and the second speaker (14) are arranged side by side in the direction perpendicular to the line segment connecting the first cancellation point (41) and the second cancellation point (42) to each other such that the positions of the first speaker (12) and the second speaker (14) in the direction of the line segment are the same as a mid-point of the first cancellation point (41) and the second cancellation point (42).

3. The active noise control system (1) according to claim 1 or 2, wherein

the predetermined seat is a seat of a vehicle, and the first speaker (12) and the second speaker (14) are arranged side by side in a front-rear direction of the vehicle on a ceiling in front of the seat of the vehicle.

4. The active noise control system (1) according to claim 1, 2, or 3, wherein

the cancellation sound generation unit includes a first microphone (13), a second microphone (15), a first adaptive filter configured to receive a noise signal indicating the noise and generate the first cancellation sound, and a second adaptive filter configured to receive a noise signal indicating the noise and generate the second cancellation sound, and
 the first adaptive filter and the second adaptive filter are configured to adapt their own transfer functions as the first cancellation sound output from the first speaker (12) and the second cancellation sound output from the second speaker (14), using an input sound from each of the first microphone and the second microphone, so that noise is canceled at the first cancellation point (41) and noise is canceled at the second cancellation point (42).

5. The active noise control system (1) according to claim 4, wherein

the cancellation sound generation unit includes a first auxiliary filter (1111), in which a transfer function ($H_1(z)$) is set, and a second auxiliary filter (1121), in which a transfer function ($H_2(z)$) is set, the first adaptive filter and the second adaptive filter are configured to update their own transfer functions using a predetermined adaptive algorithm with a difference between the input sound from the first microphone (13) and an output of the first auxiliary filter (1111) and a difference between the input sound from the second microphone (15) and an output of the second auxiliary filter (1121) as errors, and, when a transfer function in which noise is canceled at the first cancellation point (41) and the second cancellation point (42) is set in the first adaptive filter and the second adaptive filter, the respective transfer function ($H_1(z)$, $H_2(z)$) learned as a transfer function that eliminates the difference between the input sound from the first microphone (13) and the output of the first auxiliary filter (1111) and the difference between the input sound from the second microphone (15) and the output of the second auxiliary filter (1121) is set in the first auxiliary filter (1111) and the second auxiliary filter (1121).

6. A vehicle including an active noise control system (1) according to one of the preceding claims.

Patentansprüche

1. Aktives Geräuschdämpfungssystem (1) zum Reduzieren von Geräuschen, das aufweist:

einen ersten Lautsprecher (12), der dazu ausgelegt ist, einen ersten Unterdrückungston auszugeben;

einen zweiten Lautsprecher (14), der dazu ausgelegt ist, einen zweiten Unterdrückungston auszugeben; und

eine Unterdrückungstonerzeugungseinheit, die dazu ausgelegt ist, den ersten Unterdrückungston, der von dem ersten Lautsprecher (12) ausgegeben wird, und den zweiten Unterdrückungston, der von dem zweiten Lautsprecher (14) ausgegeben wird, so zu erzeugen, dass Geräusche an einem ersten im Voraus eingestellten Unterdrückungspunkt (41) unterdrückt werden und Geräusche an einem zweiten im Voraus eingestellten Unterdrückungspunkt (42) unterdrückt werden, wobei der erste Unterdrückungspunkt (41) und der zweite Unterdrückungspunkt (42) ein Punkt, wo sich normalerweise ein linkes Ohr einer Person, die auf einem vorbestimmten Sitz sitzt, befindet, bzw. ein Punkt, wo sich normalerweise ein rechtes Ohr eines Benutzers befindet, sind,

dadurch gekennzeichnet, dass der erste Lautsprecher (12) und der zweite Lautsprecher (14) nebeneinander in einer Richtung angeordnet sind, die rechtwinklig zu einem Liniensegment ist, das den ersten Unterdrückungspunkt (41) und den zweiten Unterdrückungspunkt (42) miteinander verbindet, so dass sich Positionen des ersten Lautsprechers (12) und des zweiten Lautsprechers (14) in einer Richtung des Liniensegments zwischen dem ersten Unterdrückungspunkt (41) und dem zweiten Unterdrückungspunkt (42) befinden.

2. Aktives Geräuschdämpfungssystem (1) nach Anspruch 1, wobei

der erste Lautsprecher (12) und der zweite Lautsprecher (14) nebeneinander in der Richtung angeordnet sind, die rechtwinklig zu dem Liniensegment ist, das den ersten Unterdrückungspunkt (41) und den zweiten Unterdrückungspunkt (42) miteinander verbindet, so dass die Positionen des ersten Lautsprechers (12) und des zweiten Lautsprechers (14) in der Richtung des Liniensegments die gleichen sind wie ein Mittelpunkt des ersten Unterdrückungspunkts (41) und des zweiten Unterdrückungspunkts (42).

3. Aktives Geräuschdämpfungssystem (1) nach Anspruch 1 oder 2, wobei der vorbestimmte Sitz ein Sitz eines Fahrzeugs ist und der erste Lautsprecher (12) und der zweite Lautsprecher (14) nebeneinander in einer Vorne-Hinten-Richtung des Fahrzeugs an einer Decke vor dem Sitz des Fahrzeugs angeordnet sind.

4. Aktives Geräuschdämpfungssystem (1) nach Anspruch 1, 2 oder 3, wobei

die Unterdrückungstonerzeugungseinheit ein erstes Mikrofon (13), ein zweites Mikrofon (15), ein erstes adaptives Filter, das dazu ausgelegt ist, ein Geräuschsignal zu empfangen, das das Geräusch angibt, und den ersten Unterdrückungston zu erzeugen, und ein zweites adaptives Filter, das dazu ausgelegt ist, ein Geräuschsignal zu empfangen, das das Geräusch angibt, und den zweiten Unterdrückungston zu erzeugen, umfasst und das erste adaptive Filter und das zweite adaptive Filter dazu ausgelegt sind, ihre eigenen Übertragungsfunktionen als den ersten von dem ersten Lautsprecher (12) ausgegebenen Unterdrückungston und den zweiten von dem zweiten Lautsprecher (14) ausgegebenen Unterdrückungston unter Verwendung eines Eingabetons von jedem des ersten Mikrofons und des zweiten Mikrofons anzupassen, so dass Geräusche an dem ersten Unterdrückungspunkt (41) und Geräusche an dem zweiten Unterdrückungspunkt (42) unterdrückt werden.

5. Aktives Geräuschdämpfungssystem (1) nach Anspruch 4, wobei

die Unterdrückungstonerzeugungseinheit ein erstes Hilfsfilter (1111), in dem eine Übertragungsfunktion ($H_1(z)$) eingestellt ist, und ein zweites Hilfsfilter (1121), in dem eine Übertragungsfunktion ($H_2(z)$) eingestellt ist, umfasst, wobei das erste adaptive Filter und das zweite adaptive Filter dazu ausgelegt sind, ihre eigenen Übertragungsfunktionen unter Verwendung eines vorbestimmten adaptiven Algorithmus mit einer Differenz zwischen dem Eingabeton von dem ersten Mikrofon (13) und einer Ausgabe des ersten Hilfsfilters (1111) und einer Differenz zwischen dem Eingabeton von dem zweiten Mikrofon (15) und einer Ausgabe des zweiten Hilfsfilters (1121) als Fehler zu aktualisieren und, wenn eine Übertragungsfunktion, in der Geräusche an dem ersten Unterdrückungspunkt (41) und dem zweiten Unterdrückungspunkt (42) unterdrückt werden, in dem ersten adaptiven Filter und dem zweiten adaptiven Filter eingestellt ist, die entsprechende Übertragungsfunktion ($(H_1(z), H_2(z))$) in dem ersten Hilfsfilter (1111) und dem zweiten Hilfsfilter (1121) eingestellt ist, die als eine Übertragungsfunktion gelernt

wurde, die die Differenz zwischen dem Eingabeton von dem ersten Mikrofon (13) und der Ausgabe des ersten Hilfsfilters (1111) und die Differenz zwischen dem Eingabeton von dem zweiten Mikrofon (15) und der Ausgabe des zweiten Hilfsfilters (1121) aufhebt.

6. Fahrzeug, das ein aktives Geräuschdämpfungssystem (1) nach einem der vorhergehenden Ansprüche umfasst.

Revendications

1. Système actif de régulation du bruit (1) destiné à réduire le bruit, qui comprend :

un premier haut-parleur (12) qui est configuré pour émettre un premier son d'annulation ;
un deuxième haut-parleur (14) qui est configuré pour émettre deuxième son d'annulation ; et
une unité de génération de sons d'annulation qui est configurée pour générer le premier son d'annulation émis à partir du premier haut-parleur (12) et le deuxième son d'annulation émis à partir du deuxième haut-parleur (14) d'une manière telle que le bruit est éliminé à un premier endroit d'élimination (41) réglé à l'avance et le bruit est éliminé à un deuxième endroit d'élimination (42) réglé à l'avance ; dans lequel le premier endroit d'élimination (41) et le deuxième endroit d'élimination (42) représentent un endroit où se trouve normalement une oreille gauche d'une personne qui est assise dans un siège prédéterminé et un endroit où se trouve normalement une oreille droite d'un utilisateur, respectivement ;

caractérisé en ce que le premier haut-parleur (12) et le deuxième haut-parleur (14) sont disposés côte à côte dans une direction qui est perpendiculaire à un segment de ligne qui relie le premier endroit d'annulation (41) et le deuxième endroit d'annulation (42) l'un à l'autre d'une manière telle que des positions du premier haut-parleur (12) et du deuxième haut-parleur (14) dans une direction du segment de ligne sont situées entre le premier endroit d'annulation (41) et le deuxième endroit d'annulation (42).

2. Système actif de régulation du bruit (1) selon la revendication 1, dans lequel

le premier haut-parleur (12) et le deuxième haut-parleur (14) sont disposés côte à côte dans la direction perpendiculaire au segment de ligne qui relie le premier endroit d'annulation (41) et le deuxième endroit d'annulation (42) l'un à l'autre d'une manière telle que les positions du premier haut-parleur (12) et du deuxième haut-parleur (14) dans la direction du segment de ligne correspondent à une position

située à mi-parcours entre le premier endroit d'annulation (41) et le deuxième endroit d'annulation (42).

3. Système actif de régulation du bruit (1) selon la revendication 1 ou 2, dans lequel

le siège prédéterminé est un siège d'un véhicule ; et

le premier haut-parleur (12) et le deuxième haut-parleur (14) sont disposés côte à côte dans une direction avant-arrière du véhicule sur un plafond à l'avant du siège du véhicule.

4. Système actif de régulation du bruit (1) selon la revendication 1, 2 ou 3, dans lequel

l'unité de génération de sons d'annulation englobe un premier microphone (13), un deuxième microphone (15), un premier filtre adaptatif qui est configuré pour recevoir un signal de bruit qui signale le bruit et pour générer le premier son d'annulation, et un deuxième filtre adaptatif qui est configuré pour recevoir un signal de bruit qui signale le bruit et pour générer le deuxième son d'annulation ; et

le premier filtre adaptatif et le deuxième filtre adaptatif sont configurés pour adapter leurs propres fonctions de transfert sous la forme du premier son d'annulation émis à partir du premier haut-parleur (12) et du deuxième son d'annulation émis à partir du deuxième haut-parleur (14), en utilisant un son d'entrée à partir de chacun desdits premier et deuxième microphone, d'une manière telle que le bruit est annulé au premier endroit d'annulation (41) et que le bruit est annulé au deuxième endroit d'annulation (42).

5. Système actif de régulation du bruit (1) selon la revendication 4, dans lequel

l'unité de génération de sons d'annulation englobe un premier filtre auxiliaire (1111), dans lequel on règle une fonction de transfert ($H_1(z)$) et un deuxième filtre auxiliaire (1121), dans lequel on règle une fonction de transfert ($H_2(z)$), le premier filtre adaptatif et le deuxième filtre adaptatif sont configurés pour mettre à jour leurs propres fonctions de transfert en utilisant un algorithme adaptatif prédéterminé avec une différence entre le son d'entrée émis à partir du premier microphone (13) et une sortie du premier filtre auxiliaire (1111) et une différence entre le son d'entrée émis à partir du deuxième microphone (15) et une sortie du deuxième filtre auxiliaire (1121) sous la forme d'erreurs, et, lorsqu'une fonction de transfert dans laquelle le bruit est éliminé au premier endroit d'annulation (41) et au deuxième endroit d'annulation (42) est réglée dans le premier filtre adaptatif et dans le deuxième filtre adaptatif, la fonction de trans-

fert respective ($H_1(z)$, $H_2(z)$) apprise sous la forme d'une fonction de transfert, qui élimine la différence entre le son d'entrée émis à partir du premier microphone (13) et la sortie du premier filtre auxiliaire (1111) et la différence entre le son d'entrée émis à partir du deuxième microphone (15) et la sortie du deuxième filtre auxiliaire (1121), est réglée dans le premier filtre auxiliaire (1111) et dans le deuxième filtre auxiliaire (1121).

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6. Véhicule qui englobe un système actif de régulation du bruit (1) en conformité avec l'une quelconque des revendications précédentes.

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FIG. 1

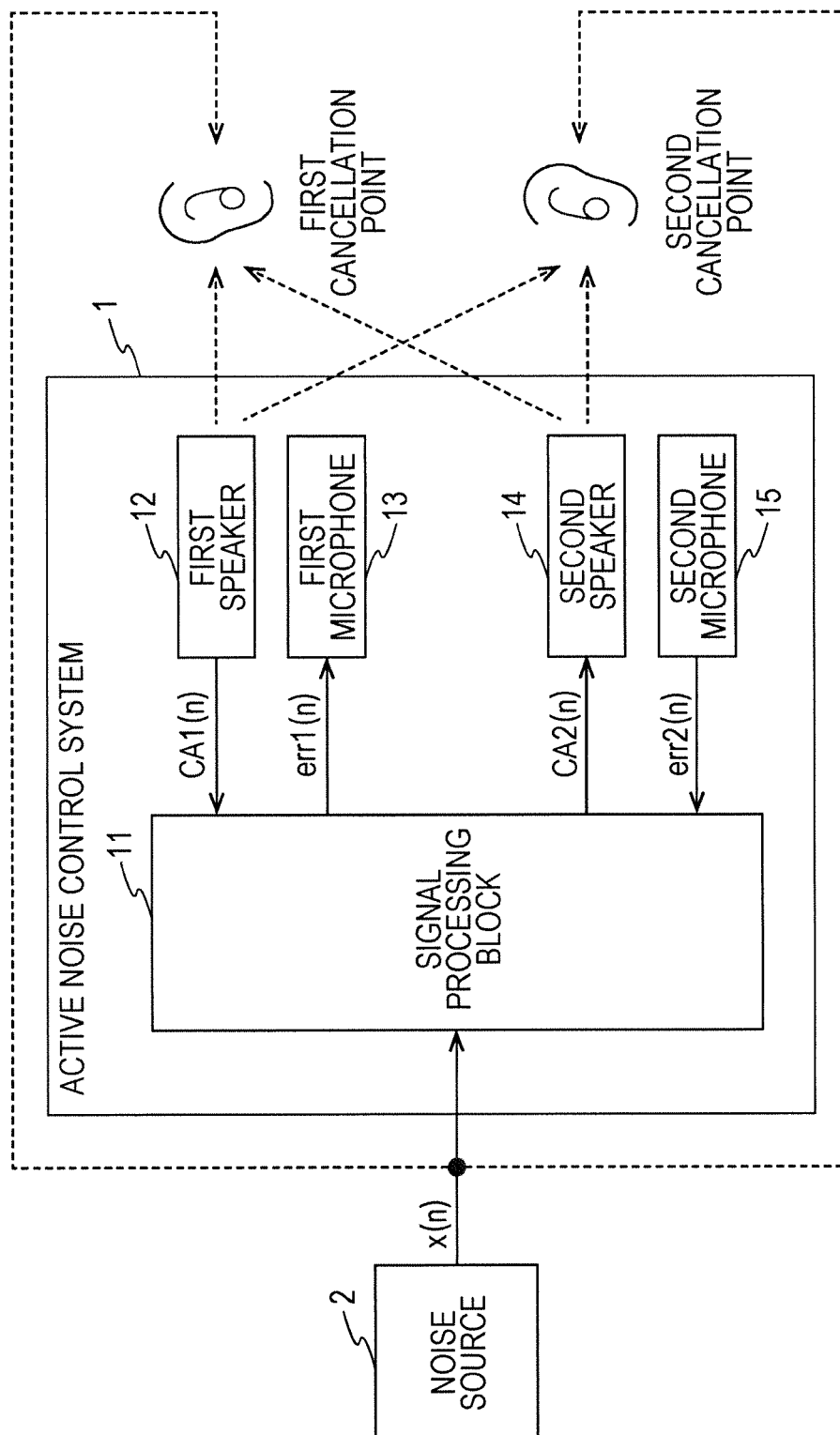


FIG. 2A1

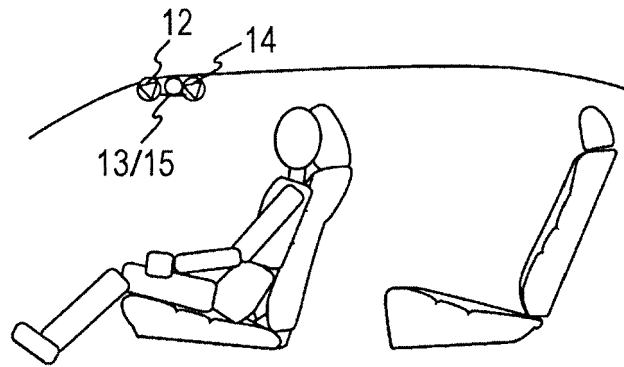


FIG. 2A2

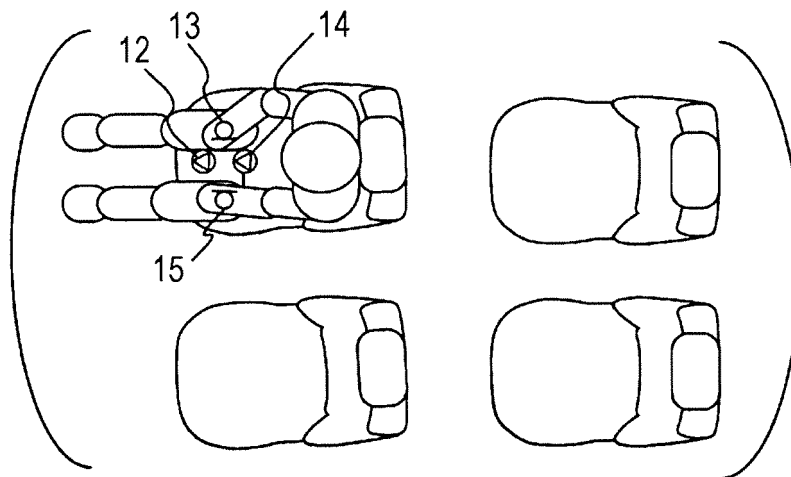


FIG. 3

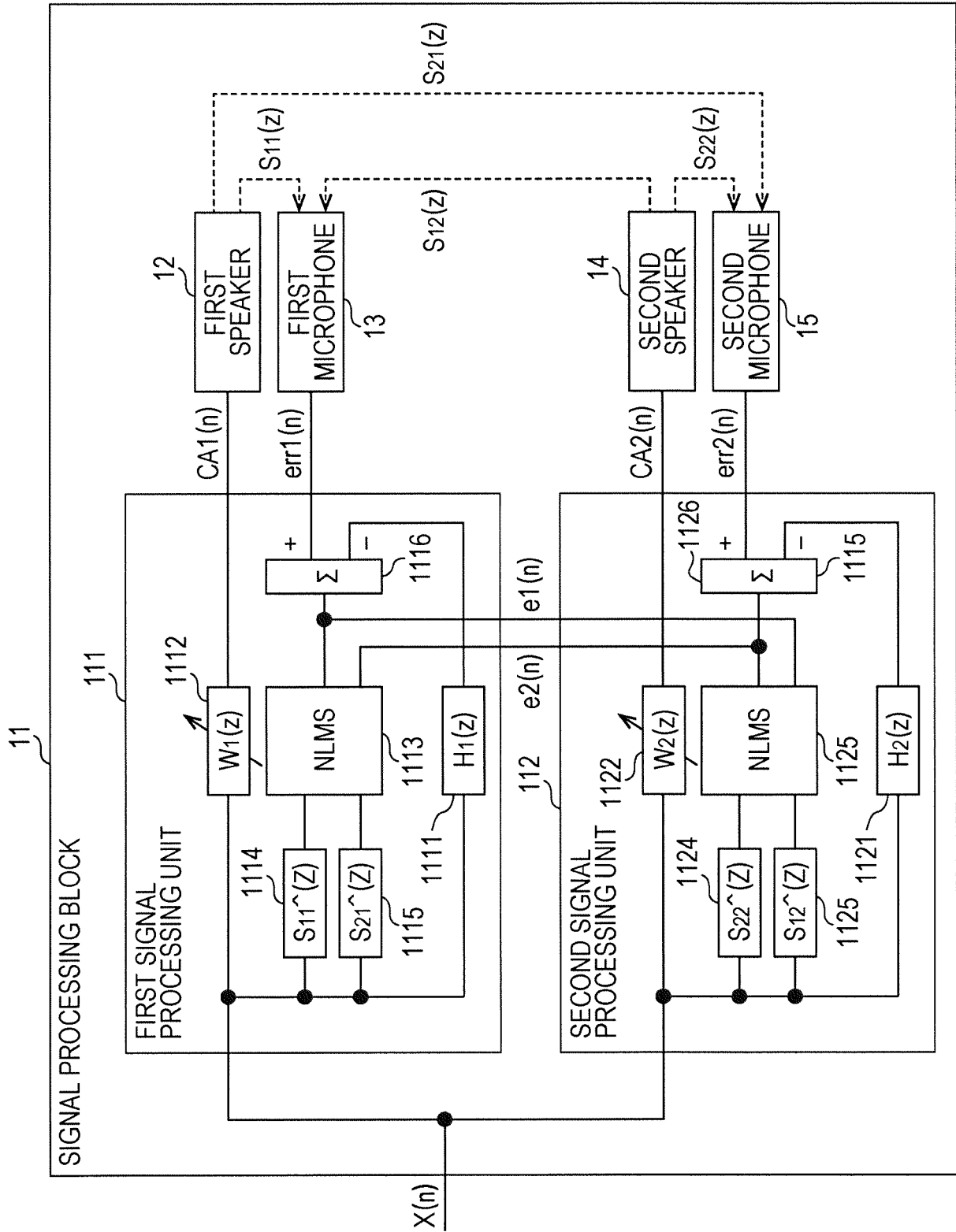


FIG. 4B

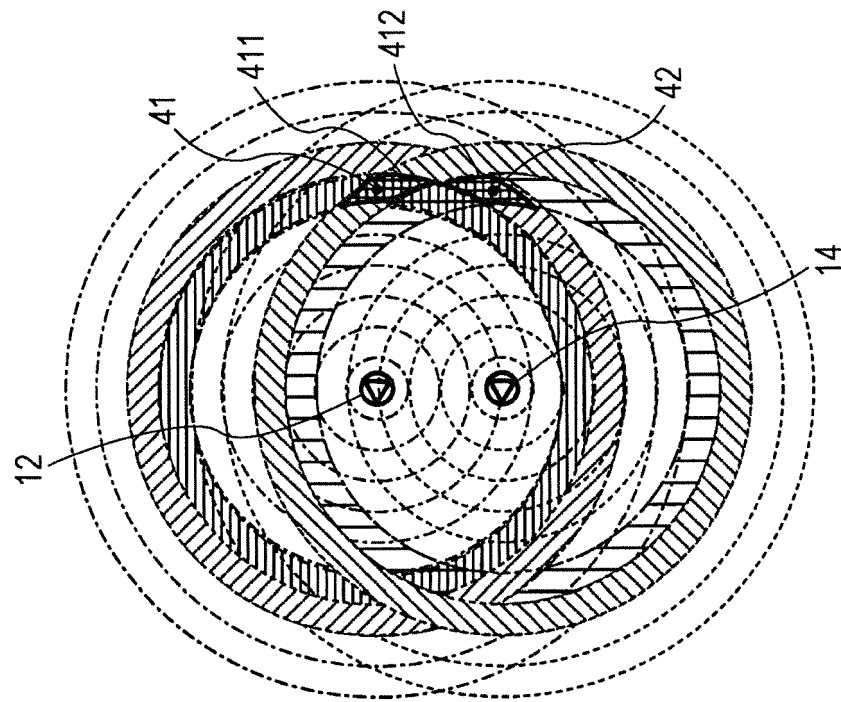


FIG. 4A

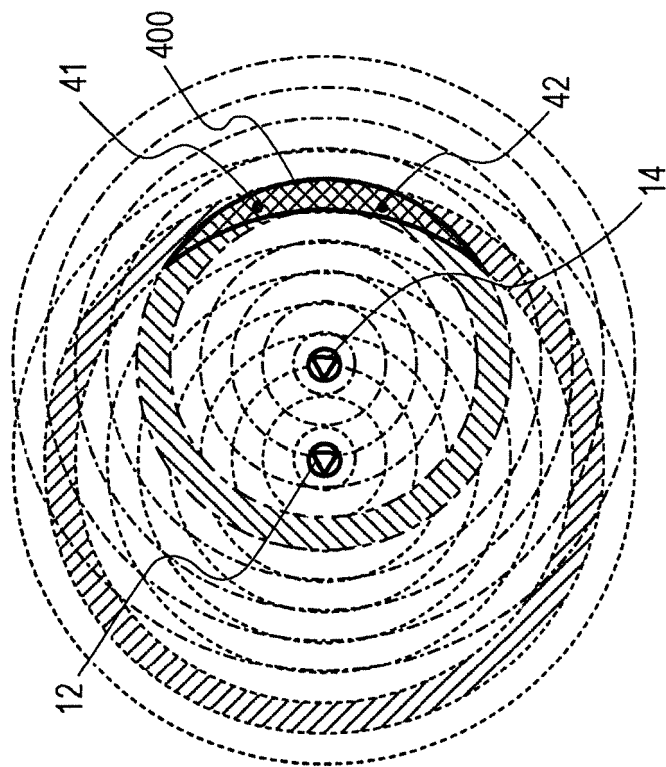


FIG. 5A

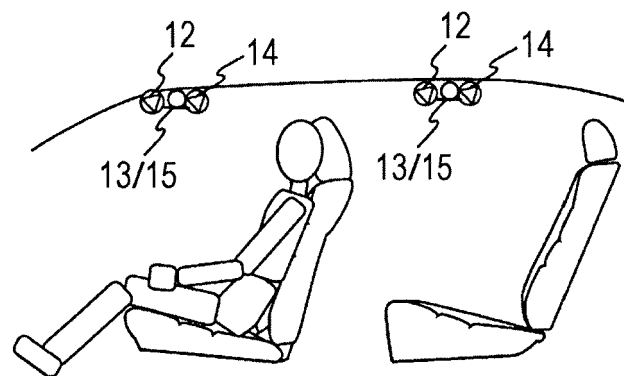
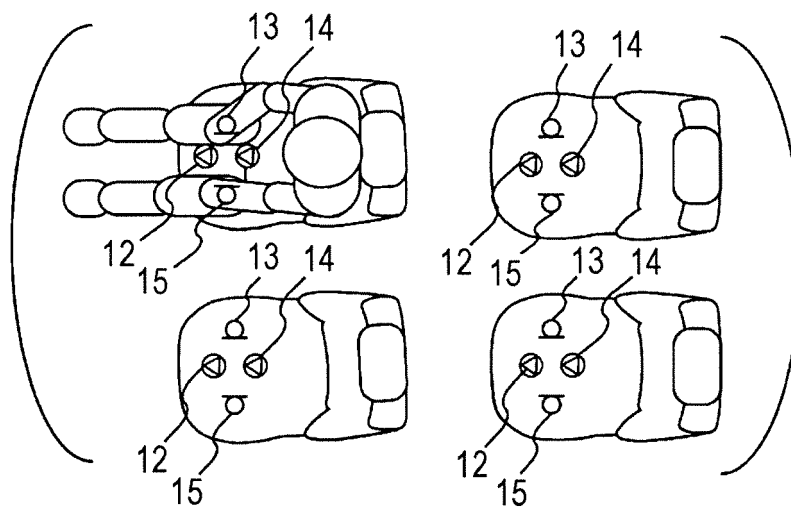


FIG. 5B



REFERENCES CITED IN THE DESCRIPTION

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